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INFLUENCE OF VOLUMETRIC AND SURFACE DEFECTS OF THE INITIAL GRINDING POWDERS OF DIAMOND GRADE AC6 ON THE CHANGE IN THEIR PHYSICAL AND MECHANICAL PROPERTIES

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The results of the investigation of the power of grinding powders diamond of brand DS with a grain size of 200/160-80/63, synthesized in Ni–Mn–C systems, presented in this article. It is shown that initial grinding diamonds distinguish between themselves for a different amount of volume and surface defects, which lead to a change in magnetic and mechanical properties. The increase in the compound of volume defects in the grinding powder of diamond with a grain size of 200/160 is twice as large in the diamonds with the inclusion of that house in the diamonds with a grain size of 80/63, which contributes to an increase in their magnetic properties by about 4 times and leads to decrease in their heat resistance by 1.5 times. The change in surface defects determined in the form of the coefficient of surface activity of diamond grinding powders of grain sizes from 200/160 to 80/63 indicates a decrease in the coefficient of surface activity of diamond grinding powders to a lesser extent for diamonds of larger sizes.

Keywords*: grinding powders of synthetic diamond, physical and mechanical characteristics, volume and* surface defects, heart resistance.

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ВПЛИВ ОБ'ЄМНИХ ТА ПОВЕРХНЕВИХ ДЕФЕКТІВ ВИХІДНИХ ШЛІФПОРОШКІВ АЛМАЗУ МАРКИ АС6 НА ЗМІНУ ЇХ ФІЗИКО-МЕХАНІЧНИХ ВЛАСТИВОСТЕЙ

У роботі наведено результати дослідження властивостей шліфпорошків алмазу марки АС6 зернистостей 200/160-80/63, синтезованих в системах Ni–Mn–C. Показано, що вихідні шліфпорошки алмазу відрізняються між собою за різним вмістом об'ємних та поверхневих дефектів, що призводить до зміни їх магнітних та механічних властивостей. Зростання вмісту об'ємних дефектів у шліфпорошках алмазу визначених кількістю неспалимих залишків для зернистості 200/160 у два рази більше у порівнянні з вмістом включень та домішок у алмазах зернистості 80/63, що сприяє посиленню їх магнітних властивостей приблизно у 4 рази та зниженню їх термостійкості у 1,5 рази. Зміна поверхневих дефектів визначених у вигляді коефіцієнту поверхневої активності шліфпорошків алмазу зернистостей від 200/160 до 80/63 свідчить про зниження коефіцієнта поверхневої активності шліфпорошків алмазу меншою мірою для алмазів більш крупних розмірів.

Ключові слова*: шліфпорошки синтетичного алмазу, фізико-механічні характеристики, об'ємні та поверхневі дефекти, термостійкість.*

Introduction and problem statement. Synthetic diamonds and tools made from them are widely used in mechanical engineering. However, the possibilities for extensive growth in the use of diamonds in industry are now practically exhausted; a sharp increase in the efficiency of their use is necessary. The performance of any diamond tool is largely determined by the properties of diamonds.

The properties of diamond powders, in turn, are determined by technologies of synthesis, extraction, processing, classification by size and shape, sorting by physical and chemical properties, surface modification, which ensures the production of powders with desired properties.

Serial diamond powders of domestic and foreign production are a set of grains of a certain grain size, which differ significantly in the main technological quality characteristics. As a rule, the value of one or another qualitative characteristic of a powder (strength, heat resistance, surface roughness, isometric) is an average value over the entire volume of the powder. Therefore, in order to obtain diamond powders that are uniform in strength and geometric characteristics, it is necessary to improve their physical-mechanical and physical-chemical properties by developing methods for influencing volumetric defects in grains by the action of force fields (gravitational, magnetic, electric) and chemical and thermochemical treatments.

But a detailed study of the process of changing the physicomechanical and physicochemical properties of synthetic diamond grinding powders and the development of new and improvement of existing methods of influencing volumetric and surface defects of abrasive diamond grains has not been carried out and there is no such information in the existing literature.

Analysis of the latest research and publications. In tool production, low-strength synthetic diamond powders AC6–AC20 are widely used in the processing of hard alloys, ceramics, glass and other

brittle materials. One of the most important ways to achieve a higher class of processed surface and increase the wear resistance of diamond tools is to increase the uniformity of diamond powders in terms of grain composition, strength, and defect content used in the tool.

In the works of Lavrinenko V.I., Pasechny O.O., Ilnitska G.D. [1-3] it has been shown that an increase in the content of the main fraction of diamond grinding powders of individual grain sizes is essential for reducing the wear rate of grinding wheels and leads to an increase in the uniformity of the linear dimensions of diamond grains, which helps to increase the wear resistance of the tool. During the operation of a diamond abrasive tool, the main type of wear of synthetic diamonds is the brittle destruction of individual protruding parts of the diamond grain due to the development of microcracks in it upon contact with the machined surface of the part. In this regard, to improve the performance of abrasive tools, it is important to improve methods for producing synthetic diamond powders for abrasive purposes with different contents of volumetric defects and with high uniformity in strength and linear dimensions.

The dimensions of diamond crystals, the number of inclusions in them and their strength largely depend on the rate at which the crystals increase in size. In the working volume of a high-pressure apparatus, it is impossible to provide equal conditions for increasing the size of all crystals due to inhomogeneity of temperature and pressure, which leads to the formation of diamond crystals with different physical and mechanical characteristics. In such cases, the inclusion represents volumetric defects in diamond crystals, which have a strong impact on the thermostability of diamonds, which directly affects the performance characteristics of the diamond tool [4, 5].

The growth of diamond crystals is accompanied by the formation of a crystal surface, that is, the boundary of a solid body with the environment. The general thermodynamic property of the surface is the excess of surface energy relative to the volume and the presence of surface tension, which affects the crystallization of diamonds and the reconstruction of their surface.

Therefore, the purpose of the work is to study the influence of volumetric and surface defects of the original AC6 diamond grinding powders on changes in their physical and mechanical characteristics

.**Research materials and methods**. The investigation of the properties of the initial grinding powders of the AS6 diamond was carried out on diamonds of grain size 200/160-80/63, synthesized in Ni–Mn–C systems.

At the Institute of Superhard Materials named after V.M. Bakulya of the National Academy of Sciences of Ukraine has developed a technology for obtaining diamond grinding powders of the AC4-AC50 grades, which includes the grinding of diamond raw material, its separation according to the size and shape of the diamond grains. According to this technology, diamond samples of grain size 200/160–80/63 were produced, in which their properties were evaluated. Research this samples was carried out using methods developed at the Institute of Superhard Materials.

The physical and mechanical characteristics of the powders were determined: strength in the form of breaking load under static compression at room temperature (P, N) and after heat treatment at 1100 °C according to the heart resistance was calculated in the form of the coefficient of thermalstability (K_{TS}), coefficients of uniformity in strength (Kunif.p) and linear dimensions (Kunif.l.d.); measured the specific magnetic susceptibility (χ), the content of the main fraction (OF). The quantitative content of surface defects was estimated by the coefficient of surface activity (Ka), volume defects in diamond grains were determined in the form of unburned residue (un/r).

Presentation of the main research material. Results and their discussion. The results of studies of initial diamond grinding powders of grain size 200/160–80/63 are presented in Table 1.

Table 1.

Characteristics of the initial diamond grinding powders of different grain sizes

Grit size	Characteristics of abrasive powders				
	OF, %	P, N	K_{TS}, %	Kunif.p., %	Kunif.l.d., %
200/160	70	9,5	21	24	20
160/125	72	7,4	22	25	22
125/100	73	6,3	29	23	21
100/80	74	5,9	30	24	20
80/63	70	4,9	32	23	18

As follows from the table. 1, the initial diamond grinding powders of various grit sizes in terms of strength are classified as AC6, the content of the main fraction in the powders is at the level of 70-74%. The coefficient of uniformity in linear dimensions is 23-18%. The heat resistance of the original powders (in the form of coefficient of thermal stability) varies for diamonds from 20 to 32%. The coefficient of uniformity in strength for diamond grinding powders is not higher than 25%.

Usually, serial diamond powders of domestic and foreign production are a set of grains of a certain granularity, which differ significantly in terms of the main technological characteristics of quality. Therefore, for diamonds with a grain size of 160/125, was performed an analysis of the diamond content by brands according to their strength (Fig. 1).

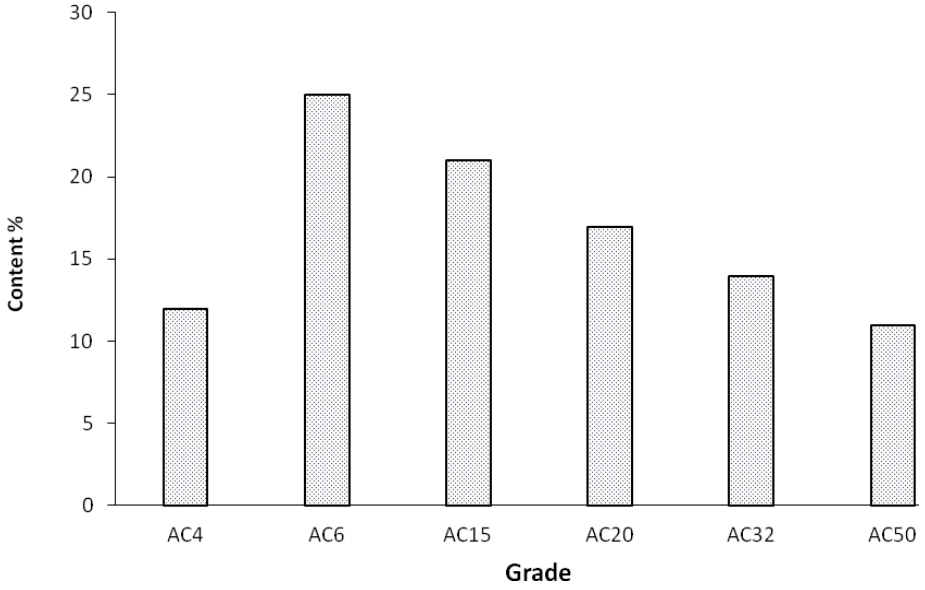

Fig. 1. **Content of diamond grains of different grades in the original diamond grinding powders of 160/125 grain size, synthesized in the systems: Ni-Mn-C**

As follows from Fig. 1, the uniformity of the initial diamond grinding powders of grade AC6 content from diamond different grades from AC4 to AS50, поэтому uniformity in strength grinding diamond of grade AC6 grit size 160/125, is 25%.

The change in the magnetic properties (in the form of a change in the specific magnetic susceptibility) of the initial diamond grinding powders of grade AC6 with grain sizes 80/63–200/160 is shown in Fig. 2.

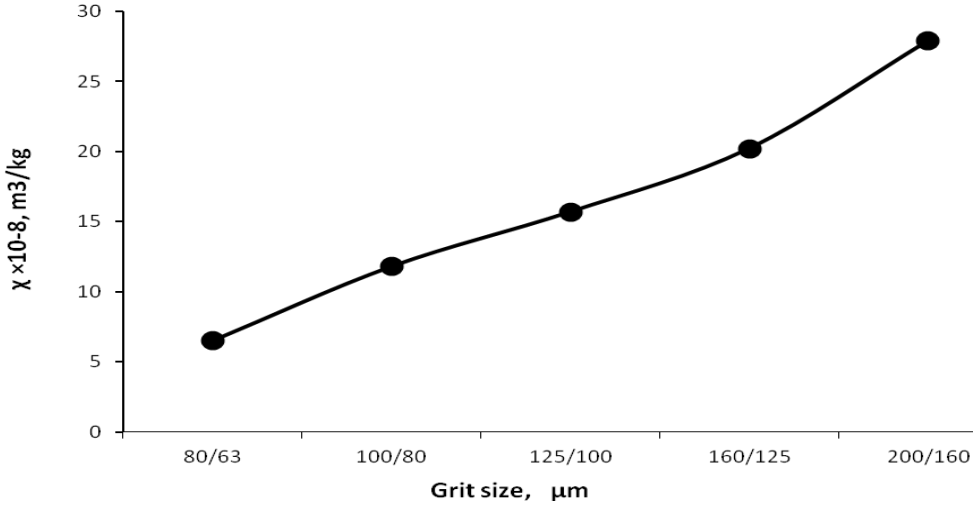

Fig.2. **Specific magnetic susceptibility of diamond grinding powders of grain size 80/63–200/**

From fig. 2 You can trace a steady trend of increasing specific magnetic susceptibility with increasing granularity of powders. Thus, the specific magnetic susceptibility of diamond grinding powders with a grain size of 200/160 is almost 4 times greater than the specific magnetic susceptibility of diamond grinding powders with a grain size of 80/63.

The increase in the content of volumetric defects, determined by the number of unburned residue (un/r) of diamond grinding powders with grain sizes 80/63–200/160, is monotonically increasing and is due to the fact that with an increase in the rate of crystal growth, the content of intracrystalline metallic inclusions captured by growing crystals from the crystallization medium increases. The increase in the content of intracrystalline inclusions and impurities is approximately two times greater for diamonds with a grain size of 200/160 compared to the content of inclusions and impurities in diamonds with a grain size of 80/63 (Fig. 3).

Analyzing the data in Fig. 4, it is clear that the decrease in the surface activity coefficient of AC6 diamond grinding powders with grain sizes from 80/63 to 250/200 is significantly less for larger diamond sizes. Thus, the surface activity coefficient for diamonds with a grain size of 80/63 is approximately 2 times greater than for diamonds with a grain size of 250/200.

Thus, the original AC6 grade diamond grinding powders with grain sizes 80/63–250/200 differ from each other in the different content of volumetric and surface defects, which leads to a change in their magnetic and mechanical properties.

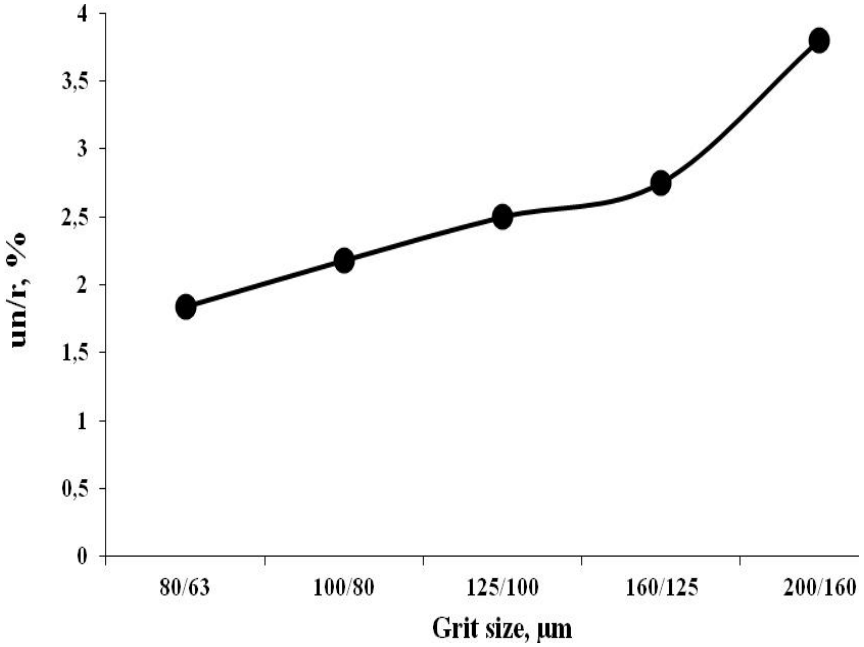

Fig 3. **Contents of intracrystalline inclusions and impurities in diamond crystals of grain size 80/63–200/160**

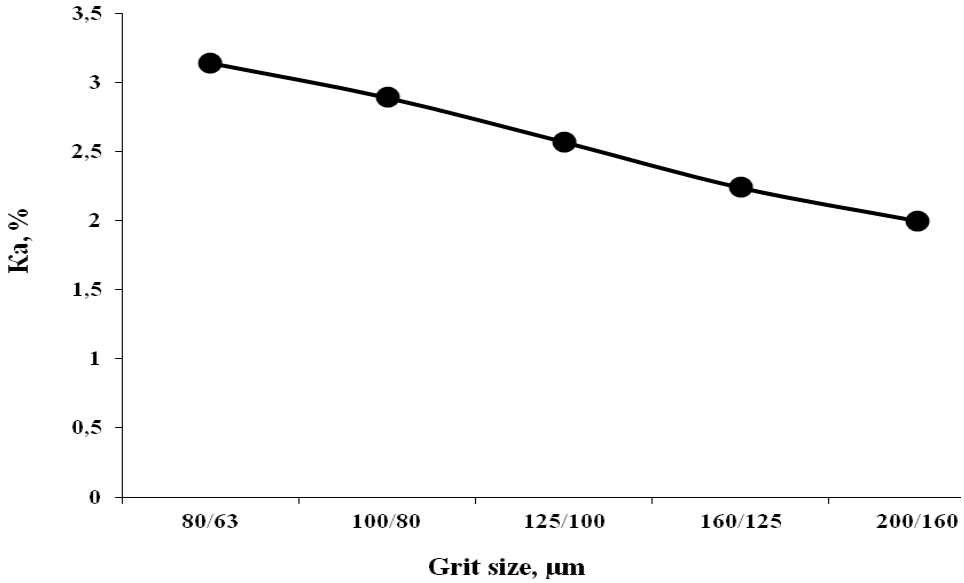

Fig 4. **Change in surface imperfections of diamond grinding powders with grain sizes 80/63–200/160**

Conclusions.

1. It has been established that the initial grinding powders of AC6 grade diamonds with grain sizes 200/160–80/63 differ from each other in the different content of volumetric and surface defects, which leads to a change in their magnetic and mechanical properties.

2. It has been shown that the increase in the content of volumetric defects, determined by the amount of unburnt residues of diamond grinding powders with a grain size of 200/160, is twice as high as compared to the content of inclusions and impurities in diamonds with a grain size of 80/63, which contributes to an increase in their magnetic properties by approximately 4 times. which helps to reduce their heat resistance (in the form of a thermal stability coefficient) by 1.5 times.

3. The change in surface defects, defined as the surface activity coefficient of diamond grinding powders with grain sizes from 200/160 to 80/63, indicates a decrease in the surface activity coefficient of diamond grinding powders to a lesser extent for larger diamond sizes.

List of sources used:

1. Lavrinenko V.I. Solid abrasive materials in machining: an encyclopedic reference book. [Text]/V.I. Lavrinenko, M.V. Novikov - K.: INM im. V.M. Bakulya NAS of Ukraine, 2013. – 456 p.

2. Superhard materials. Receipt and application [Text]. Monograph in 6 volumes / Under the general editorship. N.V. Novikov. – M.: ISM im. V.N. Bakulya, Research and Production Center "ALKON" NANU, 2007. T. 6: Diamond-abrasive tools in machining technologies / Ed. A.A. Shepelevo. – M.: ISM im. V.N. Bakulya, IPC “ALKON” NASU, 2007. – 340 p.

3. Ilnitskaya G. D. Influence of the structure of diamond crystals on the physical and mechanical properties of diamond powders // Superhard materials: creation and application. K.: INM NAS of Ukraine. – 2007. pp. 189–196.

4. Study of the possibilities of improving the performance properties of AC20 synthetic diamond grinding powders by changing their dimensional and physicochemical characteristics Lavrinenko V.I., Ilnitskaya G.D., Petasyuk G. and other Superhard materials. – 2018 – No. 4. – P. 59-70.

5. Ilnytska G.D., Lavrinenko V.I., Smokvina Diamonds for grinding tools, cut in various systems Kiev, "Vydavnitsa "Naukova Duma" NAS of Ukraine", 2021. – 167 p.

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